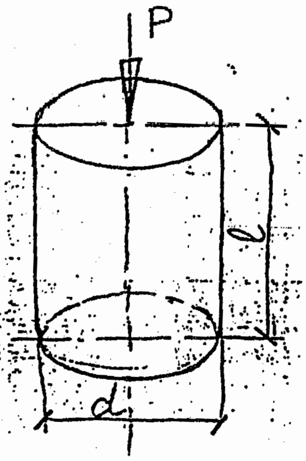
Stiffness of Symmetrical Bodies :-

$$\text{Stiffness} = \frac{\text{Load}}{\text{deformation}}.$$

1) Solid Cylinder :



$$E = \frac{\text{stress}}{\text{Strain}} = \frac{\sigma}{\epsilon}$$

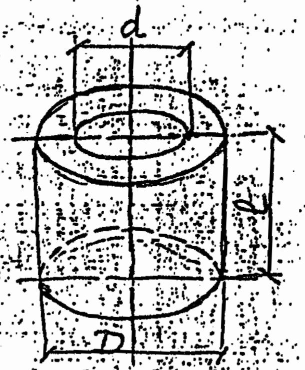
$$\sigma = P/\left(\frac{\pi d^2}{4}\right) = \frac{P}{A}$$

$$\epsilon = \Delta l / l$$

$$\therefore E = \frac{P}{A} \cdot \frac{l}{\Delta l}$$

$$\text{or } C = \frac{P}{\Delta l} = \frac{EA}{l} = \frac{E}{l}\left[\pi \frac{d^2}{4}\right]$$

2) Hollow Cylinder :



Outer diameter = D

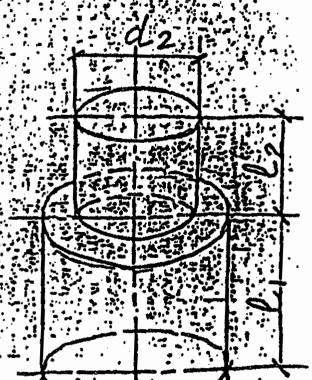
Inner diameter = d

and $A = \frac{\pi}{4}\left[D^2 - d^2\right]$

Hence

$$C = \frac{EA}{l} = \frac{E}{l}\left[\frac{\pi}{4}(D^2 - d^2)\right]$$

3) Two Cylinders in Series



$$C_1 = \frac{E_1 A_1}{l_1} = \frac{E_1}{l_1}\left[\frac{\pi}{4} d_1^2\right]$$

$$C_2 = \frac{E_2 A_2}{l_2} = \frac{E_2}{l_2}\left[\frac{\pi}{4} d_2^2\right]$$

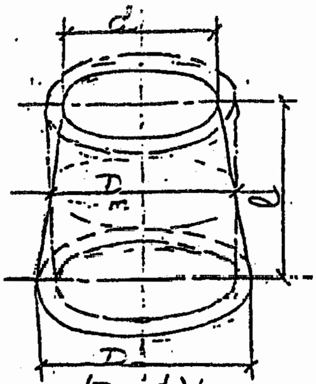
$$\frac{1}{C} = \frac{1}{C_1} + \frac{1}{C_2}$$

4) Frustum of Right Circular Cone:

Frustum diam^s are d and D

Frustum height $= l$

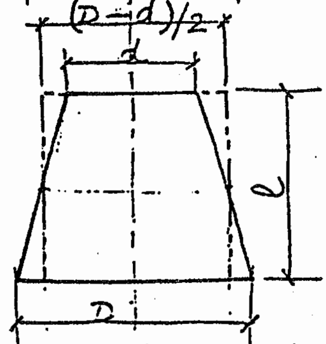
Equivalent Cyl. diam $= \frac{d+D}{2}$



$$C = \frac{E}{l}\left[\frac{\pi}{4}\left(\frac{d+D}{2}\right)^2\right]$$

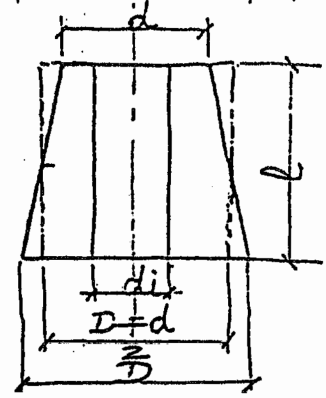
5) Frustum with axial hole:

Central hole diam $= d_i$



$$C_i = \frac{E}{l}\left(\frac{\pi}{4} d_i^2\right)$$

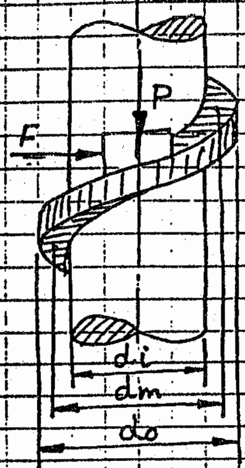
$$C_o = \frac{E}{l}\left[\frac{\pi}{4}\left(\frac{d+D}{2}\right)^2\right]$$

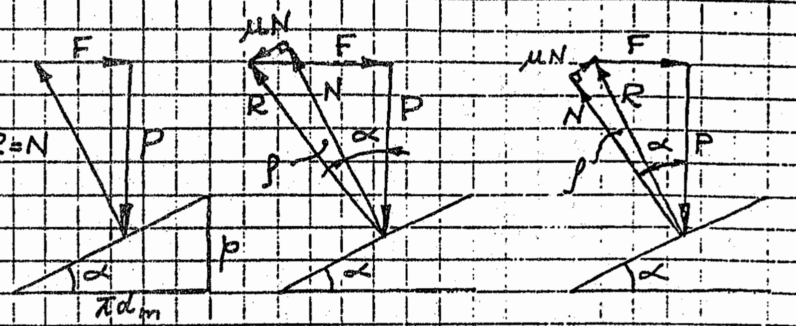


$$C = C_o - C_i$$

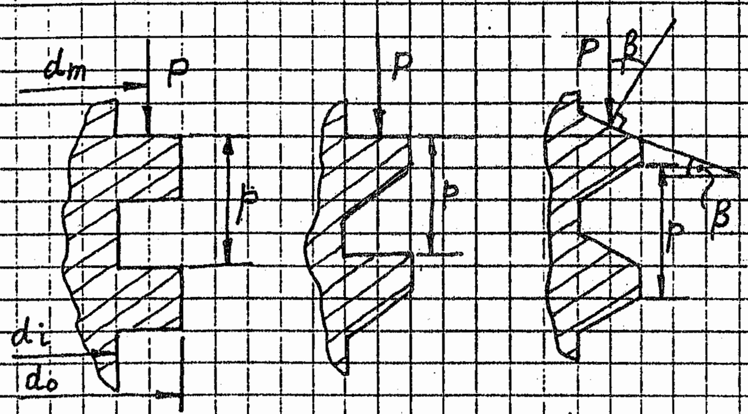
$$= \frac{\pi}{4}\frac{E}{l}\left[\left(\frac{d+D}{2}\right)^2 - d_i^2\right]$$

Forces on Axially Loaded Screw:





Frictionless	Lifting	Lowering
$F = P\tan\alpha$	$F = P\tan(\alpha+\rho)$	$F = P\tan(\alpha-\rho)$



Square Buttress Vee-thread.

Thread	β
Square	0
Buttress	0
Metric	30°
Whitworth	$27\frac{1}{2}$°
Trapizoidal	15°
Round	15°

$\tan\rho = \mu$

$\tan\alpha = p/\pi d_m$

For Square and Buttress Threads: (Lifting)

$$T_1 - \text{Thread Friction Torque} = F\frac{d_m}{2} = P\frac{d_m}{2}\tan(\alpha+\rho)$$

$$= P\frac{d_m}{2}\left[\frac{\tan\alpha + \mu}{1-\mu\tan\alpha}\right]$$

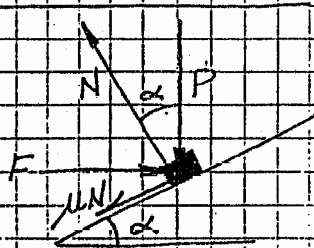
For Vee-Threads:

$$\therefore T_1 = P\frac{d_m}{2}\left[\frac{\tan\alpha + (\mu/\cos\beta)}{1-(\mu/\cos\beta)\tan\alpha}\right] = P\frac{d_m}{2}\left[\frac{\tan\alpha + \mu'}{1-\mu'\tan\alpha}\right], \quad \mu' = \frac{\mu}{\cos\beta}$$

$F = N\sin\alpha + \mu N\cos\alpha \qquad (\Sigma X = 0)$

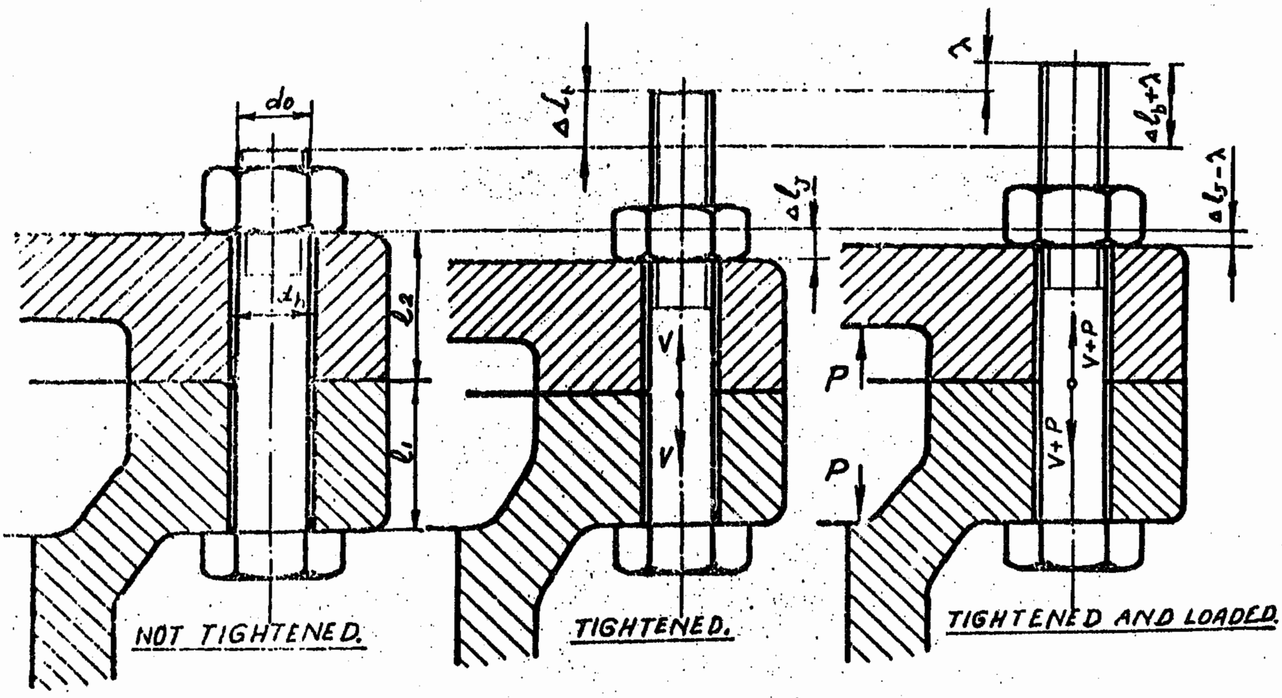
$P = N\cos\alpha - \mu N\sin\alpha \qquad (\Sigma Y = 0)$

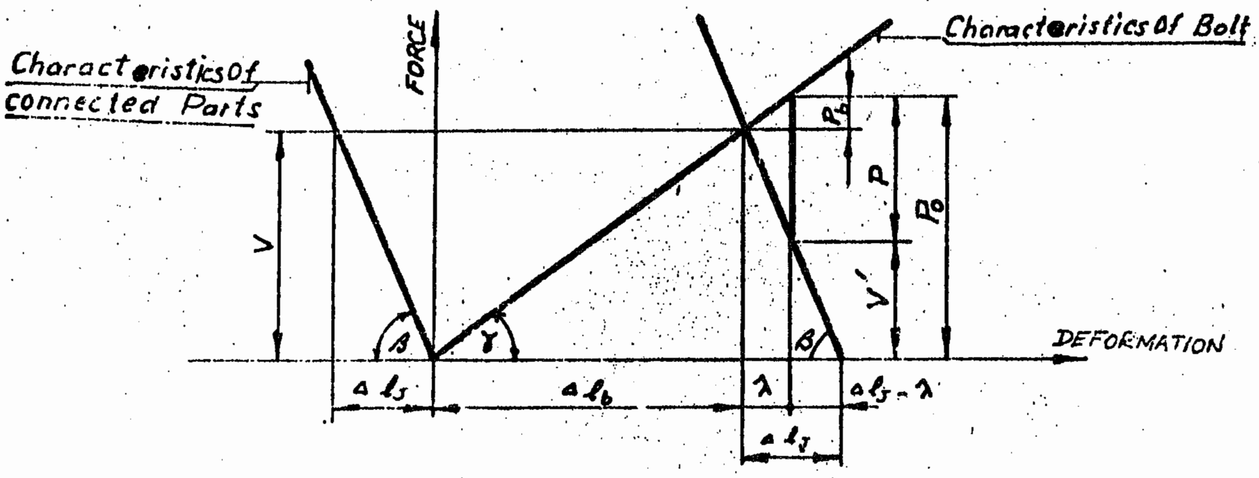
$$\frac{F}{P} = \frac{\sin\alpha + \mu\cos\alpha}{\cos\alpha - \mu\sin\alpha} = \frac{\tan\alpha + \mu}{1 - \mu\tan\alpha}$$

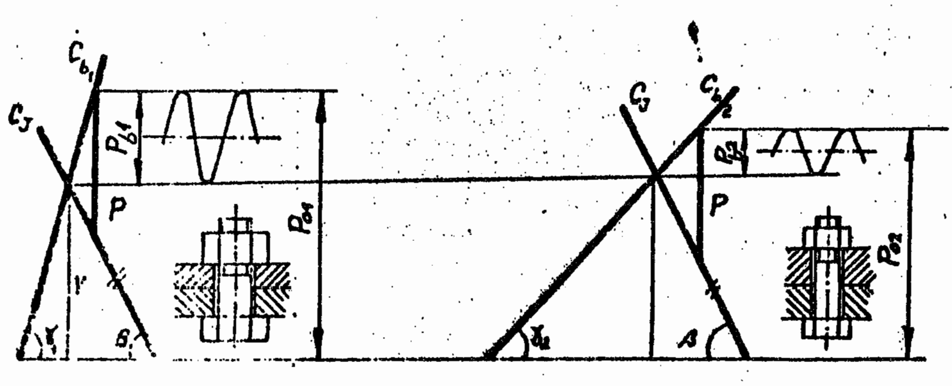


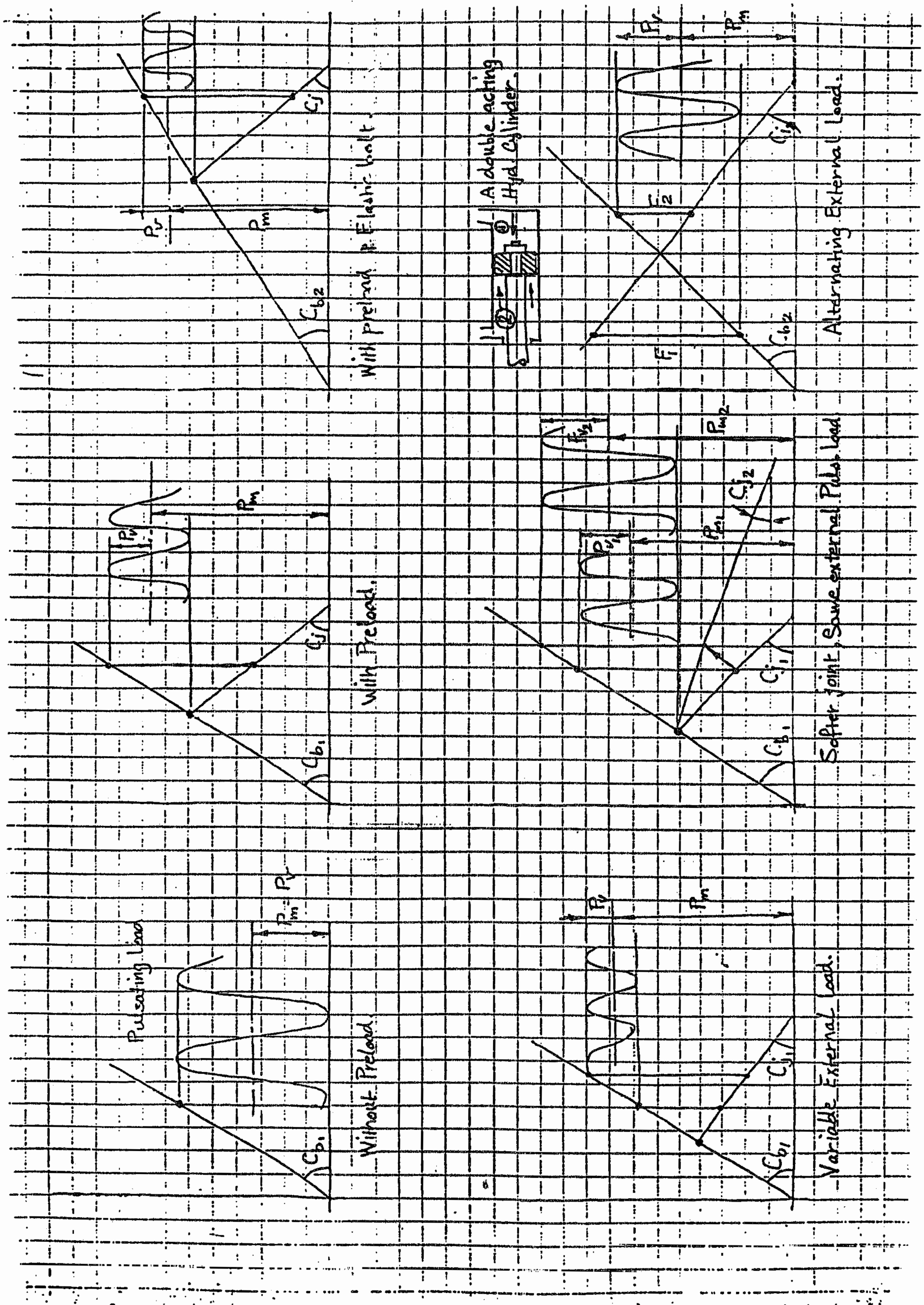
SQ. Thread.

$$\text{Thread efficiency} = \eta = \frac{\tan\alpha}{\tan(\alpha+\rho)}$$


NOT TIGHTENED.
TIGHTENED.
TIGHTENED AND LOADED.


Characteristics of connected Parts
FORCE
Characteristics of Bolt
DEFORMATION

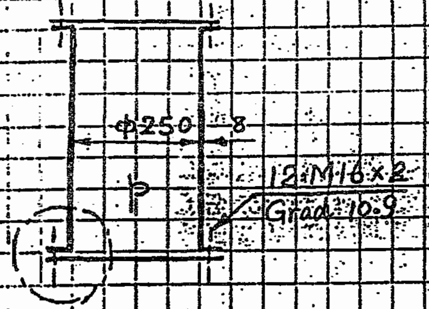




Pulsating load
Without Preload
With Preload.
With preload & Elastic bolt.
A double acting Hyd. Cylinder
Variable External Load.
Softer joint, Same external Puls. Load
Alternating External Load.

Bolted Joint under static and dynamic Loads

Ex:



p = Internal pressure = 2 M.Pa

Nate:

1 MPa = 10^6 N/m²
= 1 N/mm²
= 0.1 kg/mm²
= 10 kg/cm²

Case 1: Const p

Case 2: p_{max} = 2 MPa, P_{min} = Zero

Case 3: p_{max} = 2 MPa, p_{min} = 0.93 MPa